Table 1. Description of temporal and individual covariates used in model development to assess reproduction and survival for grizzly bears in the Greater Yellowstone Ecosystem, 1983–2001.

Covariates		Description
Sample	Study sample	Data from bears instrumented in a research trapping scenario.
	Conflict sample	Data from bears instrumented in a management trapping scenario not monitored from a previous research capture.
Temporal	Year	Year data obtained.
	Season	Subadult and adult survival for three seasons: hibernation (Nov, Dec, Jan, Feb, Mar); spring–summer (Apr, May, Jun, Jul); autumn (Aug, Sep, Oct), cub and yearling survival: active cub season (22 Apr–1 Dec), denning (2 Dec–4 Apr), active yearling season (5 Apr–22 Oct).
	Month	Month (subadult and adult survival).
	Winter severity index (WSI)	Average of 5 annual WSI values from 3 elk winter ranges in GYE.
	Whitebark pine (WBP)	Median cones/tree of all whitebark pine transects evaluated.
	Ungulate biomass (UngBio)	Estimates of annual standing biomass in 2 elk and 2 bison herds in GYE, included only in survival models for independent bears.
	Minimum population size (MinPop)	Minimum grizzly population estimated from annual counts of unduplicated females with cubs-of-the-year summed over 3 years and divided by proportion of adult females (0.274) in population.
Individual	Sex	Sex of bear.
	Age class (AgeC)	Cub, yearling, independent subadults (2–4 years) and adults (≥5 years old).
	Dependent young (DepYng)	Indicator of presence of dependent offspring (cubs-of-the-year or yearlings) for adult females.
	Prior	Binomial indicator (1 = management action, 0 = no action) in adult survival models of management actions prior to the current year.
	Residency	Proportion of annual locations in 3 mutually exclusive zones.
	InYNP	Proportion of locations inside Yellowstone National Park used as the reference location and not listed in models.
	OutYNP	Proportion of annual locations occurring in the Recovery Zone, outside YNP.
	OutRZ	Proportion of annual locations occurring outside of the RZ.

Table 2. Temporal covariates used in analysis of survival rates for grizzly bears in the Greater Yellowstone Ecosystem, 1983–2001.

Year	$\bar{x}$ winter severity index	Median whitebark pine cones/tree	Ungulate biomass (metric tons/1,000)	Minimum grizzly population
1983	1.4	12	4.50[a]	135
1984	0.3	5	4.37[a]	150
1985	-1.0	18	4.50 [a]	142
1986	0.6	0	4.74	186
1987	1.5	0	5.16	172
1988	1.6	0	5.70	208
1989	-2.0	29	5.91	175
1990	0.8	0	5.31	219
1991	-0.3	8	4.96[a]	237
1992	0.4	8	5.26	270
1993	-0.2	4	6.04	252
1994	2.0	0	6.50	237
1995	0.2	0	6.29	208
1996	-0.7	17.5	5.81[a]	255
1997	-2.2	0	5.82[a]	296
1998	2.2	5	4.66	361
1999	0.0	23	4.69	361
2000	1.0	0	5.15	383
2001	1.7	13	5.10	409
2002	1.0	0	NA	478

[a] Counts ≥1 herd(s) were missing; change over missing year(s) was averaged from differences in available counts.

Table 3. Age of first litter production for female grizzly bears in the Greater Yellowstone Ecosystem, 1983–2002.

	Statistic	SD	Lower 95% CI	Upper 95% CI
$\bar{x}$ age at first litter, years	5.8		5.6	6.3
Nulliparous producing at age 4 (%)	9.8		2.5	20.0
Nulliparous producing at age 5 (%)	29.4		13.3	47.6
Nulliparous producing at age 6 (%)	56.4	1	28.6	83.3
Nulliparous producing at age 7 (%)	100.0		100.0[a]	100.0

[a] Bootstrapping resulted in 3 iterations where all females in age class 6 successfully produced cubs. Consequently, age at first production in these 3 iterations was calculated for age classes 4–6, excluding age class 7. In all runs where age class 7 was included, all nulliparous females aged 7 produced cubs.

Table 4. Reproductive rate (female cubs/female/year) and interbirth interval (years) for adult female (>3 years old) grizzly bears in the Greater Yellowstone Ecosystem, 1983–2002.

			95% CI		
Statistic	Estimate	SE	Minimum	Maximum	*n*
Reproductive rate					
Sample unit = female	0.310	0.028	0.256	0.364	108
Sample unit = female-year	0.318	0.020	0.277	0.359	108
Interbirth interval	2.778	0.176	2.476	3.080	108

Table 5. Multinomial models predicting the probability that an adult female grizzly bear in the breeding pool produced a 0-, 1-, 2-, or 3-cub litter for the Greater Yellowstone Ecosystem. Covariates include an index to minimum population size (MinPop), median whitebark pine cone counts the autumn of breeding (WBP), female age (Age), an index of winter severity the year of breeding (WSI), bear residency (OutYNP and OutRZ), and a sample classification.

Model covariates[a]	AIC_c	Delta AIC_c	AIC_c weight	Model likelihoods	No. parameters
MinPop	273.56	0.00	0.457	1.000	6
WBP, MinPop	274.14	0.58	0.342	0.748	9
Age, MinPop	277.40	3.84	0.067	0.147	9
WSI, MinPop	278.79	5.23	0.033	0.073	9
WBP	279.80	6.24	0.020	0.044	6
OutYNP, OutRZ	279.85	6.29	0.020	0.043	9
Age	279.93	6.37	0.019	0.041	6
WBP, WSI, MinPop	280.24	6.68	0.016	0.035	12
Sample	281.70	8.14	0.008	0.017	6
WSI	281.93	8.37	0.007	0.015	6
Age, WBP	282.78	9.22	0.005	0.010	9
Sample, OutYNP, OutRZ	282.83	9.27	0.004	0.010	12
Age, WSI	284.80	11.24	0.002	0.004	9
WBP, WSI	285.87	12.31	0.001	0.002	9

[a] Data were divided into a study or conflict sample depending upon circumstance of capture and current telemetry status. Residency = OutYNP is the proportion of annual locations occurring in the Recovery Zone (RZ), outside Yellowstone National Park (YNP), or OutRZ is the proportion of annual location occurring outside of the RZ.

Table 6. Beta coefficients (SE) and goodness-of-fit statistics (Hosmer-Lemeshow $\hat{C}$ and Pearson) for models with $\Delta AIC_c < 6$ for predicting the probability that an adult female grizzly bear in the Greater Yellowstone Ecosystem breeding pool would produce a 0-, 1-, or 2-cub litter rather than a 3-cub litter, which was the reference.

Model rank	Intercept	Population index	Whitebark pine cone counts	Female age	Winter severity index	Goodness-of-fit statistics ($\hat{C}$) (P-value)	Pearson Chi^2 (P-value)
1: 2/3	-2.159 (1.34)	0.013 (0.006)				2.38 (0.79)	10.00 (0.63)
1: 1/3	-5.178 (1.79)	0.019 (0.007)				4.05 (0.54)	5.12 (0.82)
1: 0/3	-1.609 (1.30)	0.012 (0.006)				3.62 (0.61)	11.23 (0.51)
2: 2/3	-1.963 (1.34)	0.012 (0.006)	0.009 (0.032)			2.83 (0.83)	11.04 (0.61)
2: 1/3	-6.148 (2.07)	0.025 (0.008)	-0.115 (0.071)			3.14 (0.79)	8.12 (0.52)
2: 0/3	-1.488 (1.32)	0.012 (0.006)	-0.030 (0.006)			11.15 (0.19)	65.90 (0.06)
3: 2/3	-1.700 (1.49)	0.013 (0.006)		-0.532 (0.075)		5.03 (0.75)	27.34 (0.78)
3: 1/3	-3.602 (2.04)	0.019 (0.007)		-0.200 (0.131)		8.61 (0.38)	17.36 (0.57)
3: 0/3	-0.908 (1.45)	0.012 (0.006)		-0.082 (0.074)		6.64 (0.58)	62.76 (0.089)
4: 2/3	-2.214 (1.35)	0.013 (0.006)			-0.020 (0.268)	3.91 (0.79)	12.26 (0.59)
4: 1/3	-5.361 (1.86)	0.020 (0.007)			-0.070 (0.352)	2.00 (0.92)	10.38 (0.41)
4: 0/3	-1.517 (1.31)	0.011 (0.006)			0.193 (0.263)	4.83 (0.57)	12.67 (0.55)

Table 7. Distribution of mortalities of grizzly bear cubs and yearlings from the Greater Yellowstone Ecosystem, 1983–2002. The spring period started at den emergence and continued through 14 July; hyperphagia began 15 July and continued through den entrance.

		Cubs		Yearlings		
Sample	*n*	Spring	Hyperphagia	Spring	Hyperphagia	Total
Study	95	9	13	3	1	26
Conflict	42	1	9	1	0	11
Total	137	10	22	4	1	37[a]

[a] Five bears could have died as cubs or as yearlings and are not listed.

Table 8. Models constructed in Program MARK used to estimate survival of cub and yearling grizzly bears in the Greater Yellowstone Ecosystem, 1983–2001. All models also contain an intercept for cubs and yearlings that account for 2 parameters.

Model number and covariates[a]	$QAIC_c$	Delta $QAIC_c$	$QAIC_c$ weight	Model likelihood	Number parameters	QDeviance
1 OutYNP + OutRZ	165.010	0.00	0.114	1.000	4	156.85
2 OutYNP + OutRZ + WSI	165.633	0.62	0.083	0.732	5	155.39
3 OutYNP + OutRZ + MinPop	165.859	0.85	0.074	0.654	5	155.62
4 OutYNP + OutRZ + litter size	165.961	0.95	0.071	0.622	5	155.72
5 OutYNP + OutRZ + female age	166.543	1.53	0.053	0.465	5	156.30
6 OutYNP + OutRZ + WSI + litter size	166.614	1.60	0.051	0.448	6	154.28
7 OutYNP + OutRZ + WBP	166.689	1.68	0.049	0.432	5	156.45
8 litter size	166.941	1.93	0.043	0.381	3	160.85

[a] OutYNP was the proportion of annual locations occurring in the Recovery Zone (RZ) but outside Yellowstone National Park (YNP), OutRZ was the proportion of annual locations occurring outside of the RZ, and the proportion of locations within YNP served as the reference; WBP = an index of whitebark pine seed production; WSI = an index of winter severity; MinPop = minimum grizzly bear population estimated from annual counts of unduplicated females with cubs-of-the-year.

Table 9. Ranking of importance of covariates in models of cub and yearling survival for grizzly bears in the Greater Yellowstone Ecosystem, 1983–2001. Ranks are based on the $QAIC_c$ weight for each covariate summed over all models (n = 42) and the mean weight (sum weights/42). For reference, the model containing only the intercept had a $QAIC_c$ weight of 0.014, whereas the model containing only the sample covariate had a $QAIC_c$ weight of 0.005.

Covariate	n	Sum weights	Rank	$\bar{x}$	Rank
OutYNP + OutRZ	22	0.844	1	0.038	1
Winter severity index	13	0.263	3	0.020	5
Minimuim population size	14	0.251	4	0.018	6
Litter size	10	0.311	2	0.031	3
Female age	1	0.036	9	0.036	2
Female age squared	1	0.023	10	0.023	4
Whitebark pine	10	0.104	6	0.010	9
Whitebark pine previous year	4	0.051	7	0.013	7
Sample	18	0.142	5	0.008	10
Adult male mortality	2	0.010	11	0.005	11
All male mortality	3	0.037	8	0.012	8

Table 10. Beta coefficients (SE) for those models with $\Delta QAIC_c < 2$ for cub and yearling survival for grizzly bears in the Greater Yellowstone Ecosystem, 1983–2002. The mean and standard deviation (SD) are provided for standardized individual covariates.

		Covariate[a]								
Model rank	Delta $QAIC_c$	Cub intercept	Yearling intercept	OutYNP	OutRZ	WSI	MinPop	Litter size	WBP	Female age
1	0.00	6.22 (0.31)	6.90 (0.64)	0.57 (0.29)	-0.29 (0.18)					
2	0.62	6.31 (0.33)	7.07 (0.68)	0.58 (0.29)	-0.24 (0.18)	-0.25 (0.21)				
3	0.85	7.14 (0.91)	7.79 (1.05)	0.61 (0.29)	-0.17 (0.20)		-0.003 (0.003)			
4	0.95	6.26 (0.32)	6.87 (0.64)	0.48 (0.30)	-0.25 (0.18)			0.29 (0.27)		
5	1.53	6.24 (0.34)	6.90 (0.71)	0.60 (0.32)	-0.28 (0.20)					0.19 (0.30)
6	1.60	6.35 (0.34)	7.05 (0.69)	0.49 (0.30)	-0.21 (0.18)	-0.25 (0.21)		0.29 (0.28)		
7	1.68	6.06 (0.38)	6.85 (0.66)	0.57 (0.29)	-0.27 (0.18)				0.016 (0.025)	
8	1.93	6.19 (0.30)	6.87 (0.64)					0.51 (0.25)		
mean				0.4457	0.4257			2.304		9.0
SD				0.4257	0.2529			0.577		3.76

[a] OutYNP was the proportion of annual locations occurring in the Recovery Zone (RZ) but outside Yellowstone National Park (YNP), OutRZ was the proportion of annual locations occurring outside of the RZ, and the proportion of locations within YNP served as the reference; WBP = an index of whitebark pine seed production; WSI = an index of winter severity; MinPop = minimum grizzly bear population estimated from annual counts of unduplicated females with cubs-of-the-year.

Table 11. Summary of sample size, months radiomonitored, known mortalities, and unresolved or unexplained loss of grizzly bears under study and conflict settings by sex and age class, 1983–2001, in the Greater Yellowstone Ecosystem.

				Months available			Known mortalities by cause					
Sample	Sex	Age class	No. bears	Total	$\bar{x}$	SD	Human	Natural	Undetermined	Total	Unexplained and unresolved loss	Known plus unexplained and unresolved loss
Study	Female	subadult	38	388	9.9	7.4	1	0	2	3	3	6
		adult	72	1,998	27.8	19.2	4	0	0	4	6	10
	Male	subadult	47	491	10.4	6.8	2	0	0	2	0	2
		adult	109	1,304	12.0	9.3	12	4	1	17	6	23
Conflict	Female	subadult	22	325	14.8	10.6	8	0	0	8	1	9
		adult	39	709	18.2	11.0	10	0	1	11	0	11
	Male	subadult	45	326	7.2	5.9	14	0	1	15	0	15
		adult	46	448	9.7	6.9	8	1	0	9	6	15
Total			323	5,989	18.5	17.1	59	5	5	69	22	91

Table 12. Estimates of mean annual survival and process standard deviation on the logit scale for study sample grizzly bears in the Greater Yellowstone Ecosystem, 1983–2001.

	Estimates	
Parameter	Censored	Assumed dead
Mean beta, $\overline{\beta}$	1.940	1.535
95% CI β	1.452–2.429	1.078–1.993
Sex effect, $\hat{\beta}_G$	0.990	0.934
95% CI β_G	0.417–1.564	0.430–1.438
Mean annual survival males, $\overline{S}_M$	0.874	0.823
95% CI $\overline{S}_M$	0.810–0.920	0.746–0.880
Mean annual survival females, $\overline{S}_F$	0.950	0.922
95% CI $\overline{S}_F$	0.898–0.976	0.857–0.959
Process SD β_i, $\hat{\sigma}$	0.279	0.442
95% CI σ	0–0.856	0–0.977

Table 13. Annual estimates ($\bar{S}$) and shrinkage estimates ($\tilde{S}$, White et al. 2001) of survival for the study sample of grizzly bears in the Greater Yellowstone Ecosystem, 1983–2001. The $\bar{x}$ and SD are estimates of the $\bar{x}$ and total and process variation calculated from back-transformed $\bar{S}$ and $\tilde{S}$, respectively.

	Censored				Assumed dead			
	M		F		M		F	
Year	$\bar{S}$	$\tilde{S}$	$\bar{S}$	$\tilde{S}$	$\bar{S}$	$\tilde{S}$	$\bar{S}$	$\tilde{S}$
1983	0.8775	0.8745	0.9507	0.9494	0.8122	0.8157	0.9167	0.9184
1984	0.7370	0.8238	0.8830	0.9264	0.6432	0.7196	0.8210	0.8672
1985	0.8680	0.8718	0.9465	0.9482	0.8486	0.8360	0.9345	0.9284
1986	0.7542	0.8362	0.8920	0.9322	0.5261	0.6578	0.7386	0.8302
1987	0.9255	0.8896	0.9710	0.9559	0.8511	0.8379	0.9357	0.9293
1988	0.8680	0.8707	0.9465	0.9477	0.8066	0.8125	0.9139	0.9169
1989	0.9720	0.9130	0.9894	0.9658	0.9662	0.9045	0.9865	0.9601
1990	0.8125	0.8502	0.9211	0.9386	0.7881	0.8030	0.9044	0.9120
1991	1.0000	0.8748	1.0000	0.9495	1.0000	0.8231	1.0000	0.9221
1992	0.7333	0.8152	0.8810	0.9223	0.6463	0.7073	0.8230	0.8601
1993	0.9057	0.8854	0.9628	0.9541	0.8418	0.8340	0.9312	0.9275
1994	0.8571	0.8640	0.9417	0.9447	0.8351	0.8306	0.9280	0.9258
1995	0.8653	0.8685	0.9453	0.9468	0.8050	0.8096	0.9131	0.9154
1996	0.9467	0.9106	0.9795	0.9648	0.8345	0.8318	0.9277	0.9264
1997	0.9530	0.9094	0.9820	0.9643	0.9454	0.9008	0.9778	0.9585
1998	0.9688	0.9112	0.9882	0.9650	0.9318	0.8898	0.9720	0.9536
1999	0.9566	0.9120	0.9834	0.9654	0.9508	0.9059	0.9801	0.9608
2000	0.9104	0.8927	0.9647	0.9573	0.8617	0.8517	0.9406	0.9359
2001	0.8248	0.8446	0.9269	0.9360	0.7754	0.7859	0.8978	0.9033
$\bar{x}$	0.8809	0.8746	0.9503	0.9492	0.8247	0.8188	0.9180	0.9185
SD	0.0804	0.0304	0.0361	0.0134	0.1189	0.0661	0.0643	0.0343

Table 14. A priori and a posteriori models used to assess impact of individual[a] and temporal[b] covariates on estimates of grizzly bear survival in the Greater Yellowstone Ecosystem, 1983–2001. Results for a priori models with $\Delta AIC_c < 2$ are presented out of 42 models investigated. Each model also contains an intercept term which accounts for 1 parameter.

A priori model ranks and covariates	AIC_c	ΔAIC_c	AIC_c weights	Model likelihood	Parameters	Deviance
1 WBP+Season+Sample+Sex+OutYNP+OutRZ	658.000	0.000	0.1847	1.0000	8	641.976
2 WSI+WBP+Season+Sample+Sex+OutYNP+OutRZ	658.500	0.500	0.1439	0.7789	9	640.470
3 WSI+WBP+Season+Sample+Sex+OutYNP+OutRZ+AgeC	658.796	0.796	0.1241	0.6717	10	638.760
4 WBP+UngBio+Season+Sample+Sex+OutYNP+OutRZ	658.847	0.847	0.1210	0.6547	9	640.817
5 WSI+WBP+Season+Sample+Sex+OutYNP+OutRZ+DepYng	659.663	1.663	0.0804	0.4354	10	639.627
6 WSI+WBP+UngBio+Season+Sample+Sex+OutYNP+OutRZ	659.669	1.668	0.0802	0.4342	10	639.632
A posteriori model ranks (1 and 2) and top a priori model 1 for comparison						
1 WBP+Season+MgtEffect2+Sex+OutYNP+OutRZ	638.736	0.000	1.000	1.000	8	622.712
2 WBP+Season+Sample+Sex+OutYNP+OutRZ+Trend	655.102	16.366	0.000	0.000	9	637.072
1 WBP+Season+Sample+Sex+OutYNP+OutRZ	658.000	19.265	0.000	0.000	8	641.976

[a] Individual covariates: Sample = study or conflict; OutYNP was the proportion of annual locations occurring in the Recovery Zone (RZ) but outside Yellowstone National Park (YNP), OutRZ was the proportion of annual locations occurring outside of the RZ, and the proportion of locations within YNP served as the reference; AgeC (age class) = independent subadult (2–4 yr) or adult (≥5 yr); DepYng = presence of dependent offspring (cubs-of-the-year or yearlings); MgtEffect2 = years since management captures for up to 2 years since the management action.

[b] Temporal covariates: Season = hibernation (Nov, Dec, Jan, Feb, Mar), spring–summer (Apr, May, Jun, Jul), or autumn (Aug, Sep, Oct); WBP = median cones/tree of all whitebark pine transects read during 1983–2001; WSI = average of 5 winter severity indices from 3 elk winter ranges in the Greater Yellowstone Ecosystem (GYE); UngBio = an estimates of standing biomass available in 2 elk and 2 bison herd units in the GYE; Trend = trend through year 1–19 of this study.

Table 15. Sum of AIC_c weights and covariate[a] rank based on weight for all 42 a priori candidate models for grizzly bear survival in the Greater Yellowstone Ecosystem, 1983–2001.

Covariate	Sum AIC_c weights	*n*	Rank
Season	1.0000	35	1.5
Sex	1.0000	26	1.5
Sample	0.9994	26	3
Residency	0.9307	15	4
WBP	0.8502	14	5
WSI	0.5297	13	6
UngBio	0.2128	6	7
AgeC	0.1569	4	8
DepYng	0.1137	4	9
Year	0.0688	13	10
Prior	0.0536	3	11
MinPop	0.0375	2	12
Month	0.0000	2	13

[a] Season = hibernation (Nov, Dec, Jan, Feb, Mar), spring–summer (Apr, May, Jun, Jul), or autumn (Aug, Sep, Oct); Sample = study or conflict; Residency was the proportion of annual telemetry locations in 1 of 3 mutually exclusive zones: InYNP inside Yellowstone National Park (YNP), OutYNP in the Recovery Zone (RZ) but outside YNP, OutRZ outside of the RZ; WBP = median cones/tree of all whitebark pine transects read during 1983–2001; WSI = an average of 5 winter severity indices from 3 elk winter ranges in the Greater Yellowstone Ecosystem (GYE); UngBio = an estimate of standing biomass in 2 elk and 2 bison herd units in the GYE; AgeC (age class) = independent subadult (2–4 yr) or adult (5 yr and up); DepYng = presence of dependent offspring (cubs-of-the-year or yearlings); Prior = number of management actions prior to the year current data were obtained; MinPop = minimum grizzly bear population estimated from annual counts of unduplicated females with cubs-of-the-year.

Table 16. Estimates of beta coefficients on the logit scale and (SE) for individual[a] and temporal[b] covariates contained in the 6 best a priori and a posteriori models of grizzly bear survival in the Greater Yellowstone Ecosystem, 1983–2001.

	Covariates													
				Season		Residency								
A priori model ranks	Intercept	Sample	Sex	Hibernation	Spring /Summer	OutYNP	OutRZ	WBP	WSI	UngBio	AgeC	DepYng	Trend	MgtEffect2
1	3.932	-1.323	0.755	3.266	1.054	-0.206	-1.154	0.049						
	(0.341)	(0.255)	(0.256)	(0.607)	(0.282)	(0.356)	(0.379)	(0.022)						
2	3.937	-1.333	0.742	3.266	1.177	-0.213	-1.113	0.049	-0.214					
	(0.342)	(0.255)	(0.256)	(0.607)	(0.311)	(0.356)	(0.380)	(0.022)	(0.180)					
3	3.720	-1.295	0.696	3.262	1.173	-0.229	-1.109	0.050	-0.214		0.339			
	(0.377)	(0.257)	(0.259)	(0.607)	(0.311)	(0.357)	(0.380)	(0.022)	(0.181)		(0.256)			
4	2.671	-1.343	0.768	4.530	1.115	-0.207	-1.155	0.056		0.226				
	(1.219)	(0.255)	(0.256)	(1.326)	(0.289)	(0.357)	(0.378)	(0.023)		(0.212)				
5	3.942	-1.341	0.896	3.272	1.181	-0.219	-1.118	0.049	-0.217			-0.369		
	(0.342)	(0.255)	(0.315)	(0.607)	(0.310)	(0.357)	(0.380)	(0.022)	(0.179)			(0.399)		
6	2.859	-1.350	0.755	4.344	1.221	-0.211	-1.116	0.055	-0.195	0.193				
	(1.227)	(0.255)	(0.256)	(1.330)	(0.316)	(0.357)	(0.380)	(0.023)	(0.183)	(0.212)				
Posterior models														
MgtEffects2	4.338		0.652	3.049	0.793	-0.262	-1.167	0.039						-0.962
	(0.373)		(0.256)	(0.609)	(0.288)	(0.367)	(0.386)	(0.022)						(0.142)
Trend	3.370	-1.261	0.774	3.223	1.023	-0.330	-1.550	0.045					0.058	
	(0.420)	(0.256)	(0.256)	(0.608)	(0.283)	(0.364)	(0.425)	(0.022)					(0.026)	

[a] Individual covariates: Sample = study or conflict; Residency = OutYNP was the proportion of annual locations occurring in the Recovery Zone (RZ) but outside Yellowstone National Park (YNP), OutRZ was the proportion of annual locations occurring outside of the RZ, and the proportion of locations within YNP served as the reference; AgeC (age class) = independent subadult (2–4 yr) or adult (≥5 yr); DepYng = presence of dependent offspring (cubs-of-the-year or yearlings); MgtEffect2 = years since management captures for up to 2 years since management action.

[b] Temporal covariates: Season = hibernation (Nov, Dec, Jan, Feb, Mar), spring–summer (Apr, May, Jun, Jul), autumn (Aug, Sep, Oct); WBP = median cones/tree of all whitebark pine transects read during 1983–2001; WSI = average of 5 winter severity indices from 5 elk winter ranges in the Greater Yellowstone Ecosystem (GYE); UngBio = an estimate of standing biomass available in 2 elk and 2 bison herd units in the GYE; Trend = trend through year 1–19 of this study.

Table 17. Process variance estimated from 1983–2001 Yellowstone grizzly bear data and standard deviation from 2 series of simulations examining mean independent female survival rates of 0.92 and 0.95 for n = 3,000 iterations.

	Field data[a]	Simulations
Point estimate, female survival	0.950[b]	0.950
Estimated process SD, logit scale	0.279	-
Process SD 95% CI, logit scale	0.000–0.856	-
Process SD, real scale	0.013	0.013
90 percentile, yearly survival	0.926–0.965[c]	0.928–0.970
Point estimate, female survival	0.922[d]	0.920
Estimated process SD, logit scale	0.442	0.430
Process SD 95% CI, logit scale	0.000–0.977	-
Process SD, real scale	0.034	0.036
90 percentile, yearly survival	0.860–0.961[c]	0.855–0.968

[a] Haroldson et al. (2005*a*).

[b] Unresolved losses of monitored grizzlies censored.

[c] From shrinkage estimates associated with estimates after sampling variance had been removed.

[d] Unresolved losses of monitored grizzlies assumed to be deaths.

Table 18. Finite population multipliers (λ) and elasticities of the 4 parameters in 2 simple deterministic models of grizzly bear population growth in the Greater Yellowstone Ecosystem, 1983–2002.

	Independent survival 0.92		Independent survival 0.95	
Parameter	Value	Elasticity	Value	Elasticity
m_{4+}[a]	0.318[b]	0.089	0.318[b]	0.089
S_0[c]	0.630	0.089	0.650	0.089
S_1[c]	0.800	0.089	0.830	0.089
S_{2+}	0.920	0.733	0.950	0.733
λ	1.042		1.076	

[a] Schwartz et al. (2005*c*). These values were converted to appropriate F_x values in Leslie matrix formulation for calculation of elasticity.

[b] Value from Schwartz et al. (2005*c*).

[c] Schwartz et al. (2005*a*) reported mean cub survival of 0.640 and mean yearling survival of 0.817, but assumed that all cubs and yearlings died if their mother died. We adjusted cub and yearling survival accordingly to reflect the relation between dependent offspring survival and survival of mothers.

Table 19. Means and standard deviations of cub, yearling, and independent female survival rates used in the stochastic simulations of a grizzly bear population in the Greater Yellowstone Ecosystem. In all cases, n = 3,000 iterations; standard errors of values were always <0.0005, so are not reported here.

Intended independent survival	Simulated survival					
	Cub survival		Yearling survival		Independent survival	
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Lower annual process variation						
0.87	0.595	0.061	0.759	0.072	0.870	0.029
0.88	0.602	0.057	0.768	0.067	0.880	0.027
0.89	0.608	0.054	0.778	0.062	0.890	0.025
0.90	0.616	0.050	0.786	0.057	0.900	0.022
0.91	0.622	0.047	0.795	0.053	0.910	0.020
0.92	0.630	0.044	0.803	0.049	0.920	0.018
0.93	0.636	0.042	0.813	0.045	0.930	0.016
0.94	0.643	0.039	0.821	0.042	0.940	0.014
0.95	0.650	0.037	0.829	0.039	0.950	0.013
High annual process variation						
0.87	0.595	0.069	0.760	0.082	0.870	0.052
0.88	0.602	0.065	0.769	0.076	0.880	0.050
0.89	0.608	0.060	0.778	0.070	0.890	0.046
0.90	0.616	0.056	0.785	0.066	0.900	0.042
0.91	0.623	0.053	0.794	0.060	0.910	0.039
0.92	0.629	0.049	0.803	0.056	0.920	0.036
0.93	0.636	0.046	0.812	0.051	0.930	0.032
0.94	0.643	0.042	0.821	0.046	0.940	0.027
0.95	0.650	0.039	0.829	0.043	0.950	0.024

Table 20. Mean and upper and lower 90 percentiles of λ projected by stochastic simulations. We modeled hypothetical annual survival rate for independent female using 2 levels of annual process variation for grizzly bears in the Greater Yellowstone Ecosystem. Also shown are lower 5th and upper 95th percentiles of annual independent female survival from simulations. In all cases, n = 3,000 iterations.

Annual independent female survival			λ		
$\bar{x}$	5th percentile	95th percentile	$\bar{x}$	5th percentile	95th percentile
Low annual process variation					
0.870	0.820	0.917	0.983	0.962	1.003
0.880	0.834	0.923	0.995	0.975	1.013
0.890	0.848	0.929	1.006	0.989	1.022
0.900	0.862	0.935	1.018	1.002	1.033
0.910	0.876	0.942	1.029	1.015	1.043
0.920	0.889	0.948	1.040	1.027	1.053
0.930	0.902	0.955	1.052	1.040	1.064
0.940	0.916	0.963	1.063	1.052	1.074
0.950	0.928	0.970	1.074	1.064	1.084
High annual process variation					
0.870	0.777	0.944	0.982	0.945	1.015
0.880	0.791	0.949	0.994	0.959	1.025
0.890	0.808	0.954	1.005	0.971	1.035
0.900	0.823	0.958	1.017	0.987	1.043
0.910	0.840	0.963	1.028	1.001	1.053
0.920	0.855	0.968	1.040	1.014	1.063
0.930	0.873	0.972	1.051	1.028	1.071
0.940	0.891	0.976	1.062	1.042	1.080
0.950	0.907	0.981	1.074	1.057	1.089

Table 21. Rates of change of grizzly bear population simulations for the Greater Yellowstone Ecosystem with high process variance, calculated according to 3 alternative calculations: (1) the antilog of the least squares regression slope of ln(females) on time; (2) the geometric mean slope where n = number of females; and (3) the arithmetic mean of each of the 9 ratios of successive population size. Each set of values was produced by 3,000 iterations, and standard errors in each case were <0.0004, so are not presented.

Independent female survival	$\lambda = e^r$ (Regression)			$\lambda = n_{10}/n_1^{(1/9)}$ (Geometric mean)			$\lambda = \sum_{i=1}^{9} \frac{n_{i+1}}{n_i} / 9$ (Arithmetic mean)		
	$\bar{x}$	SD	$\lambda < 1$	$\bar{x}$	SD	$\lambda < 1$	$\bar{x}$	SD	$\lambda < 1$
0.87	0.9824	0.0220	0.781	0.9823	0.0211	0.796	0.9844	0.0206	0.769
0.88	0.9939	0.0202	0.604	0.9938	0.0195	0.609	0.9956	0.0190	0.571
0.89	1.0053	0.0193	0.369	1.0053	0.0184	0.372	1.0069	0.0180	0.329
0.90	1.0168	0.0173	0.161	1.0167	0.0168	0.155	1.0180	0.0164	0.137
0.91	1.0285	0.0160	0.045	1.0285	0.0153	0.043	1.0296	0.0150	0.035
0.92	1.0397	0.0152	0.010	1.0398	0.0146	0.008	1.0407	0.0143	0.034
0.93	1.0513	0.0132	0.002	1.0513	0.0125	0.001	1.0521	0.0123	0.001
0.94	1.0624	0.0115	-	1.0625	0.0111	-	1.0631	0.0109	-
0.95	1.0741	0.0010	-	1.0741	0.0096	-	1.0746	0.0095	-

Table 22. Probability of observing a decline in the Greater Yellowstone Ecosystem grizzly bear population between any 2 successive years (given a perfect census), under alternative mean rates of independent female survival, with associated mean λ and probability that λ < 1 within 10 years. For each set of simulations, *n* = 3,000 iterations.

Mean independent female survival	Mean λ	*P* (λ) < 1 10-years	*P* (λ) < 1 between any 2 successive years
0.87	0.982	0.781	0.554
0.88	0.994	0.604	0.483
0.89	1.005	0.369	0.407
0.90	1.017	0.161	0.322
0.91	1.028	0.045	0.238
0.92	1.040	0.010	0.164
0.93	1.051	0.002	0.098
0.94	1.062	<0.001	0.049
0.95	1.074	<0.001	0.020

Table 23. Means and standard deviations of cub and yearling survival rates for the Greater Yellowstone Ecosystem grizzly bear population used in the stochastic simulations along with resulting λ, comparing basic projections (assuming high process variance) with those in which variation of yearly survival was increased. Standard errors of values were always <0.0005, so are not reported here.

Independent female survival	Cub survival		Yearling survival		λ		
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$P < 1.0$
0.87[a]	0.595	0.069	0.760	0.082	0.984	0.022	0.781
0.87[b]	0.594	0.101	0.752	0.117	0.983	0.023	0.772
0.95[a]	0.650	0.039	0.829	0.043	1.074	0.010	0.000
0.95[b]	0.648	0.091	0.821	0.101	1.074	0.012	0.000

[a] No added process variation to cub and yearling survival, $n = 3{,}000$ iterations.

[b] Cub and yearling survival variation increased, $n = 6{,}000$ iterations.

Table 24. Means and standard deviations of m_x, survival rates for independent female grizzly bears, and λ, comparing basic projections (assuming high process variance) with those in which all survival and fecundity rates varied among iterations with magnitude similar to the total variance (i.e., not merely process variance) observed in the Greater Yellowstone Ecosystem during 1983–2002. Raw SD for annual independent female survival was 0.064 when treating unresolved losses as deaths and 0.036 when treating unresolved losses as censored (Haroldson et al. 2005*a*). Standard errors of simulation results were always <0.0005, so are not reported here.

Intended independent survival	m_x		Independent survival		λ		
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$P < 1.0$
0.92[a]	0.317	0.043	0.920	0.036	1.040	0.015	0.010
0.92[b]	0.323	0.068	0.919	0.071	1.037	0.068	0.229
0.95[a]	0.318	0.037	0.950	0.024	1.074	0.010	0.000
0.95[b]	0.323	0.054	0.951	0.029	1.074	0.034	0.032

[a] Process variance only, n = 3,000 iterations.

[b] Total (i.e., process and sampling) variance, n = 6,000 iterations.